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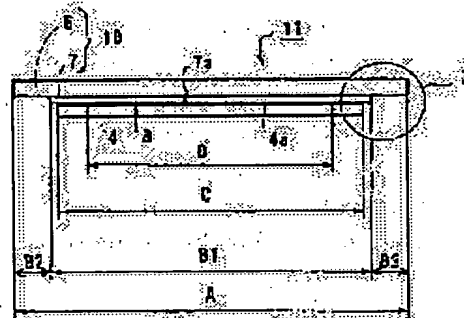
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## (54) POLARIZED LIGHT SEPARATION ELEMENT

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a polarized light separation element being easily manufactured and having high reliability.

**SOLUTION:** A diffraction optical element (10) is produced by forming a resin layer (7) having a diffraction grating plane (7a) on a surface on a glass substrate (6) and a liquid crystal layer (3) adjacent to the diffraction grating plane (7a) is composed of a nematic or smectic liquid crystal. A counter flat plate (4) is adjacent to the liquid crystal layer (3) in such a way that it interposes the liquid crystal layer (3) between the resin layer (7) and itself and is provided with an alignment layer (4a) to align the liquid crystal on the surface of the liquid crystal layer (3) side. A non-forming region (B2) on which no resin layer (7) is formed exists on the glass substrate (6). The counter flat plate (4) is arranged so as not to be deviated from a forming region (B1) of the resin layer (7) to the non-forming region (B2).



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**CLAIMS**

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[Claim(s)]

[Claim 1] The diffracted-light study component which forms the resin layer which has the diffraction-grating side which imprinted the metal mold configuration on a glass substrate, and grows into a front face, The liquid crystal layer which consists of the liquid crystal which has form birefringence, and adjoins said diffraction-grating side, The polarization separation component which is a polarization separation component equipped with the transporence substrate for adjoining a liquid crystal layer as said liquid crystal layer is pinched between said resin layers, and enclosing liquid crystal, and is characterized by being arranged so that said transporence substrate may not overflow the formation field of said resin layer.

[Claim 2] Polarization separation component according to claim 1 characterized by being satisfied with following conditional-expression \*\* and \*\*, and a list of conditional-expression \*\* or \*\* while said diffraction lattice plane constitutes a blaze configuration;

$1.5 < H < 6$  — \*\*  $0.1 < \Delta n < 0.3$  — \*\*  $n_p \neq n_o$  — \*\*  $n_p \neq n_e$  — \*\*, however H: — the value of the larger one of diffraction-grating height (micrometer) and  $\Delta n$ : refractive-index difference  $|n_p - n_o|$  and  $|n_p - n_e|$ , the refractive index of  $n_p$ : resin layer, the refractive index of the liquid crystal layer to  $n_o$ : Tsunemitsu, and the refractive index of the liquid crystal layer to the abnormality light in  $n_e$ : — it comes out.

[Claim 3] The polarization separation component according to claim 1 or 2 characterized by the thickness of said liquid crystal layer being 50 micrometers or less.

[Claim 4] The polarization separation component according to claim 1, 2, or 3 to which said resin layer is characterized by being the resin layer which has the weld flash which is higher than a diffraction lattice plane at the periphery.

[Claim 5] The diffracted-light study component which forms the resin layer which has the diffraction-grating side which imprinted the metal mold configuration on a glass substrate, and grows into a front face, The liquid crystal layer which consists of the liquid crystal which has form birefringence, and adjoins said diffraction-grating side, The compound-die component which is a compound-die component equipped with the transporence substrate for adjoining a liquid crystal layer as said liquid crystal layer is pinched between said resin layers, and enclosing liquid crystal, and is characterized by being arranged so that said transporence substrate may not overflow the formation field of said resin layer.

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the polarization separation component used for the illumination-light study system for illuminating a liquid crystal panel in a liquid crystal projector about a polarization separation

component.

[0002]

[Description of the Prior Art] In the space light modulation element which performs image display by the light modulation of specific polarization like a liquid crystal panel, since illumination light other than specific polarization is absorbed with a polarizer, generally the abbreviation one half of the illumination light serves as quantity of light loss. In order to solve this problem and to raise efficiency for light utilization, the various proposals of the illumination-light study system which performs polarization conversion by separation of polarization and rotation of plane of polarization (namely, plane of vibration of an electric vector) are made. For example, by the illumination-light study system given in JP,10-197827,A, the plane of polarization of the two linearly polarized lights is made the same by dividing the illumination light from a lamp into the two linearly polarized lights the linearly polarized lights and plane of polarization cross at right angles mutually with a polarization separation component, having separated while and rotating 90 degrees of plane of polarization of the linearly polarized light with 1/2 wavelength plate. By this polarization conversion, since incidence only of the linearly polarized light to which plane of polarization was equal can be carried out to a polarizer, most quantity of light loss by the polarizer is lost, and achievement of the high lighting of efficiency for light utilization is attained to a space light modulation element.

[0003]

[Problem(s) to be Solved by the Invention] The polarization separation component given in JP,10-197827,A consists of a diffraction grating which consists of the isotropic transparent body, an optically anisotropic body layer which consists of a birefringence ingredient. However, since a diffraction grating is an optic which has the fine structure, while constituting this from a single member, it is difficult [ it ] to keep the dependability high. And the ease of manufacture in consideration of a moldability is also required of a diffraction grating.

[0004] this invention is made in view of such a situation — having — manufacture — it is easy and aims at offering a reliable polarization separation component.

[0005]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the polarization separation component of the 1st invention The diffracted-light study component which forms the resin layer which has the diffraction-grating side which imprinted the metal mold configuration on a glass substrate, and grows into a front face, The liquid crystal layer which consists of the liquid crystal which has form birefringence, and adjoins said diffraction-grating side, It is the polarization separation component equipped with the transparence substrate for adjoining a liquid crystal layer, as said liquid crystal layer is pinched between said resin layers, and enclosing liquid crystal, and is characterized by being arranged so that said transparence substrate may not overflow the formation field of said resin layer.

[0006] In the configuration of invention of the above 1st, the polarization separation component of the 2nd invention is characterized by being satisfied with following conditional-expression \*\* and \*\*, and a list of conditional-expression \*\* or \*\* while said diffraction lattice plane constitutes a blaze configuration.  $1.5 < H < 6$  — \*\*0.1 —  $< \Delta n < 0.3$  —  $n_p - n_o$  —  $n_p - n_e$  — \*\*, however H: — the value of the larger one of diffraction-grating height (micrometer) and  $\Delta n$ : refractive-index difference,  $|n_p - n_o|$  and  $|n_p - n_e|$ , the refractive index of  $n_p$ :resin layer, the refractive index of the liquid crystal layer to  $n_o$ :Tsunemitsu, and the refractive index of the liquid crystal layer to the abnormality light in  $n_e$ : — it comes out.

[0007] The polarization separation component of the 3rd invention is characterized by the thickness of said liquid crystal layer being 50 micrometers or less in the configuration of the above 1st or the 2nd invention.

[0008] The polarization separation component of the 4th invention is characterized by said resin layer being a resin layer which has the weld flash which is higher than a diffraction lattice plane at the periphery in the configuration of the above 1st, the 2nd, or the 3rd invention.

[0009] The diffracted-light study component which the compound-die component of the 5th invention forms the resin layer which has the diffraction-grating side which imprinted the metal mold configuration on the front face on a glass substrate, and changes, The liquid crystal layer which consists of the liquid crystal which has form birefringence, and adjoins said diffraction-grating side, It is the compound-die component equipped with the transparence substrate for adjoining a liquid crystal layer, as said liquid crystal layer is pinched between said resin layers, and enclosing liquid crystal, and is characterized by being arranged so that said transparence substrate may not overflow the formation field of said resin layer.

[0010]

[Embodiment of the Invention] Hereafter, the polarization separation component and illumination-light study

system which carried out this invention are explained, referring to a drawing. In addition, the same sign is given to the parts same mutual and the corresponding parts of operation, such as a gestalt, and duplication explanation is omitted suitably.

[0011] << — polarization separation component ( drawing 1 - drawing 3 )>> which has a sheet-like diffracted-light study component layer — the polarization separation component (1) which has a sheet-like diffracted-light study component layer (2) in drawing 1 is shown in cross section. This polarization separation component (1) is equipped with the diffracted-light study component layer (2) of a surface relief mold (thickness modulation mold), the liquid crystal layer (3) which consists of a pneumatic liquid crystal or a smectic liquid crystal, and an opposite plate (4) and a sealing compound (5) as main components. A diffracted-light study component layer (2) consists of the transparence sheet made of resin which has optical abbreviation isotropy, and has the diffraction-grating side (2a) of a blaze configuration. The liquid crystal layer (3) which adjoins this diffraction-grating side (2a) is an optically uniaxial optically anisotropic body layer which has an optical anisotropy, and the opposite plate (4) which adjoins a liquid crystal layer (3) as whose liquid crystal layer (3) is pinched between diffracted-light study component layers (2) is a transparence substrate the product made of resin, or glass. The orientation film (4a) is prepared in the field by the side of the liquid crystal layer (3) of an opposite plate (4), and rubbing processing is performed so that liquid crystal may carry out homogeneous orientation to the orientation film (4a) along the direction of a slot of a diffraction lattice plane (2a).

[0012] As for a diffracted-light study component layer (2), consisting of thermoplastics is desirable. As thermoplastics, PA (polyamide), PE (polyethylene), PS (polystyrene), PVC (polyvinyl chloride), PMMA (polymethyl methacrylate), amorphous polyolefine system resin, etc. are mentioned, for example. If thermoplastics is used as a component of a diffracted-light study component layer (2), since injection molding will become possible, a diffracted-light study component layer (2) can be manufactured cheaply. moreover, an opposite plate (4) and a diffracted-light study component layer (2) — abbreviation — it is desirable to have the same coefficient of linear expansion. coefficient of linear expansion — abbreviation — since it will be hard coming to generate peeling by the part of a sealing compound (5) even if a diffracted-light study component layer (2) and an opposite plate (4) expand or contract by environmental variations (temperature change etc.) if it is made the same, high dependability can be attained. coefficient of linear expansion — abbreviation — in order to make it the same, it is still more desirable that it is desirable to constitute an opposite plate (4) and a diffracted-light study component layer (2) from the same quality of the material, and it both consists of resin which has optical abbreviation isotropy.

[0013] Since the liquid crystal enclosed between the diffracted-light study component layer (2) and the opposite plate (4) is a birefringence ingredient which has an optical anisotropy, it differs from the refractive index to Tsunemitsu, and the refractive index to abnormality light. Therefore, the diffraction operations which the diffraction-grating side (2a) optically located in a boundary with \*\*\* diffracted-light study component layers (2), such as abbreviation, does also differ with Tsunemitsu and abnormality light. With this polarization separation component (1), each ingredient is chosen so that the refractive index to either Tsunemitsu or the abnormality light may become the same as the refractive index of a diffracted-light study component layer (2). For example, when the refractive index of a liquid crystal layer (3) and the refractive index of a diffracted-light study component layer (2) to Tsunemitsu are made the same, a diffraction-grating side (2a) will be penetrated without Tsunemitsu's receiving a diffraction operation, and abnormality light will deviate in response to the diffraction operation in respect of a diffraction grating (2a). On the contrary, when the refractive index of a liquid crystal layer (3) and the refractive index of a diffracted-light study component layer (2) to abnormality light are made the same, a diffraction-grating side (2a) will be penetrated without abnormality light receiving a diffraction operation, and Tsunemitsu will deviate in response to the diffraction operation in respect of a diffraction grating (2a).

[0014] By making a liquid crystal layer (3) adjoin a diffraction-grating side (2a) as mentioned above, plane of polarization can divide the illumination light which has carried out incidence into the two linearly polarized lights which intersect perpendicularly mutually. And since the diffraction lattice plane (2a) has constituted the blaze configuration, high diffraction efficiency is acquired. Since polarization conversion efficiency will also become high if the diffraction efficiency in a diffraction-grating side (2a) is high, it is possible to raise efficiency for light utilization.

[0015] In polarization separation of the illumination light by the above-mentioned polarization separation component (1), incidence of the illumination light may be carried out from which [ of a diffracted-light study component layer (2) and the opposite plates (4) ]. However, it is more desirable than a diffraction-grating side (2a) to make thin moderately the optical member located in a injection side. Since the illumination light which carries

out incidence to a polarization separation component (1) did not polarize, even if turbulence arises in the polarization condition until it arrives at a diffraction-grating side (2a), it is satisfactory. However, if turbulence arises in the polarization condition in the optical member passed after polarization dissociating in respect of a diffraction grating (2a), polarization separation efficiency will fall and the desired engine performance will no longer be obtained. As a cause which turbulence produces, the form birefringence of an optical member is mentioned to a polarization condition. Even if it constitutes an optical member from \*\*\*\* transparency members, such as abbreviation, optically, the effect of a birefringence becomes large, so that the thickness is large, and possibility that turbulence will arise in the polarization condition by it becomes high. Since the effect of a birefringence will become small if an optical member is made thin, it is possible to suppress turbulence of a polarization condition. And there is also a merit that the transparency effectiveness in the optical member becomes high, by things thinly about an optical member.

[0016] As for the thickness of the optical member located in a injection side rather than a diffraction-grating side (2a) from the above-mentioned viewpoint, it is desirable that it is 0.1-1mm. Especially, it is desirable for the thickness of a diffracted-light study component layer (2) to be 0.1-1mm. Thus, even if it injects the polarization after separation from a diffracted-light study component layer (2) side by using the diffracted-light study component layer (2) fabricated in the shape of [ thin ] a film, it is possible to prevent turbulence of the polarization condition under the effect of said birefringence. Moreover, in case a diffracted-light study component layer (2) is fabricated by resin, since the thinner one can fabricate easily, it is desirable, and a cost cut is also possible. However, if a diffracted-light study component layer (2) is made thinner than 0.1mm in thickness, since mechanical reinforcement will fall, the handling becomes difficult.

[0017] Still more detailed explanation is given about the thickness of a diffracted-light study component layer (2). Although it is desirable that form birefringence is not shown in directions [ target / optical ] as for optical materials, such as optical plastics and optical glass, it has form birefringence slightly in fact. As a cause which shows form birefringence, the stress which remains inside an optical material in the case of shaping, the mechanical external force which joins a Plastic solid, the stress produced in a Plastic solid in the temperature gradient by heating and cooling are mentioned.

[0018] The optical path difference produced by the above-mentioned birefringence is expressed with the following formulas (FA). Moreover, optical-path-difference delta (nm) by the birefringence in each optical material at the time of d=1 (cm) is shown in Table 1.

delta=B-sigma-d — (FA) however the optical-path-difference (nm) B:opto elastic constant (x10<sup>-12</sup>/Pa) by delta:birefringence, the stress difference (105Pa) produced in sigma:optical material, and the thickness (cm) of d:optical material — it comes out.

[0019]

[Table 1]

光学材料	δ (nm)
PMMA	— 6
PMMA (ゲート付近)	5 0
PC	7 2
非晶質ポリオレフィン系樹脂	6
光学ガラス	0.2~5

[0020] The two linearly polarized lights separated with the polarization separation component (1) shown in drawing 1 turn into the two linearly polarized lights which have the same plane of polarization by rotating 90 degrees of plane of polarization of the linearly polarized light of one of these. 1/2 wavelength plate (26, drawing 11 - drawing 13) used for the illumination-light study system mentioned later, for example is used as a plane-of-polarization rotation means to rotate plane of polarization. 1/2 wavelength plate is a phase plate made to rotate 90 degrees of plane of polarization by giving 1/2 wave of optical path difference to one linearly polarized light. Therefore, unless the optical path difference delta by the birefringence is a value (about several %) small enough (as opposed to 273nm which is 546.1nm one half in the case of e line) to the one half of the wavelength of the light, the function of polarization conversion is no longer attained fully.

[0021] Generally, optical plastics has thing form birefringence 10 or more times compared with the small optical glass of form birefringence. For this reason, turbulence arises in that polarization condition and the function of

primary polarization separation is no longer achieved as each linearly polarized light by which polarization separation was carried out in respect of the diffraction grating (2a) progresses the inside of the resin of a diffracted-light study component layer (2), when the illumination light from a lamp (20, drawing 11 – drawing 13) progresses to the diffracted-light study component layer made of resin (2) from a liquid crystal layer (3). The effect of the birefringence which the resin ingredient itself has is large, and even if it is the same resin ingredient, the effect of the birefringence by the internal stress which remains inevitably at the time of shaping is also large. For example, in injection molding, since big internal stress remains near the gate (namely, resin inlet), the birefringence in the location becomes large.

[0022] Although form birefringence in case thickness  $d$  is 1 (cm) is shown, with near the gate and PC of PMMA, as for the value  $\delta$  shown in Table 1, it turns out that a quite big birefringence arises. In order to lose the effect, it is effective to make thickness of optical plastics small. For example, since the optical path difference  $\delta$  by the birefringence in PMMA (near the gate) to e line (wavelength of  $\lambda = 546.1\text{nm}$ ) is 50 (nm) by thickness  $d = 1$  (cm), it is large. [ of the effect of a birefringence ] If thickness  $d$  is made into 1 (mm) extent of 1/10, since it will become a value small enough on the order of 5 (nm) extent to wavelength  $\lambda = 546.1$  (nm), the effect of a birefringence stops however, becoming a problem. Since it becomes impossible to maintain mechanical reinforcement as mentioned above when thickness is too small, the thickness of 0.1 (mm) extent is needed. As a result, it is desirable for the thickness of a diffracted-light study component layer (2) to be within the limits of 0.1–1 (mm) extent irrespective of the quality of the material, and when it constitutes a diffracted-light study component layer (2) from optical plastics, especially the thing to carry out to the thickness of the range of 0.1–1 (mm) is desirable.

[0023] As for a diffraction-grating side (2a), it is desirable that it is satisfied with following conditional-expression \*\* and \*\*, and a list of conditional-expression \*\* or \*\*. Polarization separation efficiency can be raised by fulfilling these conditions. If the minimum of conditional-expression \*\* is exceeded, the diffraction-grating height to a diffraction-grating pitch will become large too much, and it will be hard coming to generate diffraction to slanting incident light. For this reason, diffraction efficiency will fall. It is also the same as when the upper limit of conditional-expression \*\* is exceeded. Although it is effective to use liquid crystal as a birefringence ingredient when the optically anisotropic body layer which has form birefringence is constituted simply and cheaply, what exceeds the upper limit of conditional-expression \*\* as liquid crystal is not known. Moreover, if the minimum of conditional-expression \*\* is exceeded, formation of a diffraction-grating side (2a) will become difficult.

[0024]  $1.5 < H < 6$  —  $0.1 < \delta < 0.3$  —  $n_p > n_o$  —  $n_p > n_e$  — \*\* Correct. H: Diffraction-grating height (micrometer),  $\delta$ : The value of the larger one of refractive-index difference  $|n_p - n_o|$  and  $|n_p - n_e|$ , the refractive index of  $n_p$ : diffracted-light study component layer (2), and the optically anisotropic body layer to  $n_o$ : Tsunemitsu — [ — an optically anisotropic body layer [ here as opposed to the refractive index of liquid crystal layer (3) ], and the abnormality light in  $n_e$ . ] — [ — here — the refractive index of liquid crystal layer (3) ] — it comes out.

[0025] Moreover, it is desirable for a diffraction-grating side (2a) to satisfy following conditional-expression \*\*. The miniaturization on the layout at the time of using a polarization separation component (1) for an illumination-light study system is possible for conditional-expression \*\*, and, moreover, the conditions which can attain high polarization separation efficiency are specified. If the minimum of conditional-expression \*\* is exceeded, since it is hard coming to generate the diffraction to slanting incident light, diffraction efficiency will fall. If the upper limit of conditional-expression \*\* is exceeded, since polarization part elongation will become small, it will be necessary to lengthen conjugation length, and miniaturization becomes difficult.

[0026]  $5 < D < 15$  — \*\*, however D: diffraction-grating pitch (micrometer) — it comes out.

[0027] The wavelength dependency of the transparency effectiveness ( $E_0$ , zero-order diffracted light) in a polarization separation component (1) and diffraction efficiency ( $E_1$ , +primary diffracted light) is shown in the graph of drawing 2. It is the diffraction-grating pitch  $D = 8.5$  (micrometer) of a diffracted-light study component layer (2), diffraction-grating height  $H = 2.75$  (micrometer), and refractive-index  $n_p = 1.52$ , and is  $\approx 3.8$  (degree) whenever [ angle-of-diffraction / of the +primary diffracted light ]. Moreover, it is refractive-index  $n_o = 1.52$  to Tsunemitsu and abnormality light of a liquid crystal layer (3), and  $n_e = 1.72$  (therefore  $\delta = 0.2$ ).

[0028] The incident angle dependency of the transparency effectiveness ( $E_{0R}$ ,  $E_{0G}$ ,  $E_{0B}$ ; zero-order diffracted light) in the polarization separation component (1) to the light (R: 633nm, G: 532nm, B: 473nm) of each wavelength of R, G, and B and diffraction efficiency ( $E_{1R}$ ,  $E_{1G}$ ,  $E_{1B}$ ; +primary diffracted light) is shown in the graph of drawing 3. In R, G, and B, diffraction efficiency ( $E_{1R}$ ,  $E_{1G}$ ,  $E_{1B}$ ) can acquire 50% or more of high effectiveness in the range whose transparency effectiveness ( $E_{0R}$ ,  $E_{0G}$ ,  $E_{0B}$ ) is  $\approx 20$  degrees whenever [ 90% or more and incident angle ] so that drawing 3 may show.

[0029] Polarization separation component ( drawing 4 - drawing 10 )>> which has <<compound-die diffracted-light study component The polarization separation component (11) which has a diffracted-light study component (10) in drawing 5 is shown in cross section. Moreover, the formation process of the diffraction-grating side (7a) of a diffracted-light study component (10) is shown in drawing 4 in cross section. This polarization separation component (11) is equipped with the diffracted-light study component (10) of the compound die and surface relief mold which forms the resin layer (7) which has a diffraction-grating side (7a) on a glass substrate (6), and grows into a front face. The liquid crystal layer (3) which adjoins a diffraction lattice plane (7a) consists of the pneumatic liquid crystal or the smectic liquid crystal. Moreover, the opposite plate (4) which adjoins a liquid crystal layer (3) as whose liquid crystal layer (3) is pinched between resin layers (7) It is a transparence substrate the product made of resin, or glass, and the orientation film (4a) by which rubbing processing was carried out like said polarization separation component (1) so that liquid crystal might carry out homogeneous orientation along the direction of a slot of a diffraction lattice plane (7a) is prepared in the field by the side of the liquid crystal layer (3) of an opposite plate (4).

[0030] In case a diffraction-grating side (7a) is formed, UV (ultraviolet ray) hardening mold resin is applied on the core metal mold (15) first shown in drawing 4 , a glass substrate (6) is carried on it, and UV irradiation is performed, after pressing so that resin may become predetermined thickness. If UV hardening mold resin hardens, the periphery of a glass substrate (6) will be pushed and released from mold by the ejector (16). The resin layer (7) which consists of UV hardening mold resin which has the diffraction-grating side (7a) of a blaze configuration on a front face according to this process is obtained. Since a resin layer (7) is not formed in the part which contacts an ejector (16) among all the fields (A) of a glass substrate (6) in the case of mold release, as shown in drawing 5 , on a glass substrate (6), the formation field (B1) in which the resin layer (7) is formed, the agenesis field (B-2) in which the resin layer (7) is not formed, and \*\* will exist.

[0031] A sealing compound (5 drawing 6 ) is applied on the resin layer (7) obtained as mentioned above, and an opposite plate (4) is fixed. At this time, an opposite plate (4) is arranged so that the formation field (B1) of a resin layer (7) may not be overflowed into an agenesis field (B-2). Since the field (D) of a liquid crystal layer (3) is regulated by the sealing compound (5) and the field (C) of an opposite plate (4) turns into a staging area of a field (D) and a field (B1) among the formation fields (B1) of a resin layer (7), the size relation of  $D < C < B1 < A$  will be materialized between each field.

[0032] In the formation process of the above-mentioned diffraction lattice plane (7a), it is resin which entered the clearance between core metal mold (15) and an ejector (16), and as shown in drawing 6 (the Z section enlarged drawing of drawing 5 ), weld flash (7b) will be formed in coincidence. 30 micrometers or less of thickness of a liquid crystal layer (3) are about several micrometers preferably to the height of weld flash (7b) being set to about 50-100 micrometers. If an opposite plate (4) appears on weld flash (7b) and an inclination and a float arise on an opposite plate (4), it will become impossible to control the thickness of a liquid crystal layer (3), although the thickness of a liquid crystal layer (3) is usually controlled by the about 5-10-micrometer spacer (un-illustrating). The orientation near the middle of a liquid crystal layer (3) becomes random, so that a liquid crystal layer (3) becomes thick, and a liquid crystal layer (3) stops functioning normally as an optically anisotropic body layer (for example, it becomes cloudy). If weld flash (7b) is shaved off so that an opposite plate (4) may not appear on weld flash (7b), the above-mentioned problem will not be produced, but cost will become high if processing for it is increased. Moreover, since a fine blemish will arise in a resin layer (7) if weld flash is deleted, if the environmental variations at the time of use (temperature change etc.) are severe, a crack will occur in a resin layer (7) by making the fine blemish into a generation source:

[0033] In order to solve the above-mentioned problem, the opposite plate (4) is arranged so that the formation field (B1) of a resin layer (7) may not be overflowed into an agenesis field (B-2). Since according to this configuration an opposite plate (4) does not appear on it even if there is weld flash (7b), it is possible to control the thickness of a liquid crystal layer (3) with a spacer, and liquid crystal can be thinly enclosed between a resin layer (7) and an opposite plate (4). Moreover, since the post-processing process cutting off weld flash (7b) is unnecessary, a cost rise is not caused and the blemish leading to a crack is not attached to a resin layer (7). therefore, manufacture — it is easy and can consider as a reliable polarization separation component (11).

[0034] As shown in drawing 6 , when it leaves without deleting weld flash (7b), there is a possibility that weld flash (7b) may be missing and a crack may arise in a resin layer (7). then, in order to prevent the chip of weld flash (7b) etc., it is shown in drawing 7 — as — a protective agent (8) — weld flash (7b) — a wrap — things are desirable. As a protective agent (8), flexible ingredients, such as silicone rubber, are suitable. Moreover, since weld flash (7b) consists of UV hardening mold resin in contact with an ejector (16), even if it is the edge of a resin layer (7), it

does not produce weld flash (7b) into the part which does not contact an ejector (16). If there is no weld flash (7b), the protective agent (8) is unnecessary, but in order to compensate the function of a sealing compound (5), it is desirable to also cover the edge of the resin layer (7) which does not have weld flash (7b) as shown in drawing 8 with a protective agent (8). Since there is no contact of an ejector [ as opposed to a glass substrate (6) in the part of the liquid crystal inlet (5a) shown in drawing 9 ] (16), even if it is the edge of a resin layer (7), weld flash (7b) is not produced. What is necessary is just to cover the part of this liquid crystal inlet (5a) with encapsulant (9), as shown in drawing 10 . As encapsulant (9), silicone rubber, UV hardening mold resin, etc. are mentioned.

[0035] In a polarization separation component (11), the use range through which the illumination light actually passes is the field (D) of a liquid crystal layer (3). And the periphery parts (for example, [the part of a sealing compound (5), the part of the encapsulant (9) of a liquid crystal inlet (5a)], etc.) of a liquid crystal layer (3) are non-used fields other than a use field (D). When the sealing compound (5) and encapsulant (9) in a non-used field are constituted from UV hardening mold resin etc. and light hits there in the case of actual use, light is absorbed, it has heat, or resin itself deteriorates by the exposure of long duration, and there is a possibility that it may become impossible to maintain dependability. Moreover, the refractive index of liquid crystal or resin changes with temperature changes, and there is also a possibility that the diffraction efficiency of a diffracted-light study component (10) may fall. Then, it is desirable to form the thin mask plate (for example, metal reflecting plate which consists of stainless steel etc.) which reflects light, and to interrupt the illumination light from the light source so that light may not hit the above-mentioned non-used field.

[0036] about the polarization separation component (11) shown in drawing 5 as well as the polarization separation component (1) of drawing 1 , in order to raise polarization separation efficiency, it is desirable for a diffraction-grating side (7a) to be satisfied with said following conditional-expression \*\* and \*\*, and a list of conditional-expression \*\* or \*\* — [— however,  $n_p$  is the refractive index of a resin layer (7). ]. Moreover, as for the thickness of a liquid crystal layer (3), it is desirable that it is 50 micrometers or less. If the thickness of a liquid crystal layer (3) exceeds 50 micrometers, it will become difficult to carry out orientation of the liquid crystal by the orientation film (4a), the orientation near the middle of a liquid crystal layer (3) will become random, and it will become difficult to obtain the desired engine performance (diffraction efficiency):

[0037] <<illumination-light study system ( drawing 11 - drawing 13 )>> The cross section (condition seen from the top-face side) of a color-separation optical path shows the optical configuration of the illumination-light study system equipped with the above-mentioned polarization separation component (1 or 11) to drawing 11 , and the cross section (condition seen from the side-face side) of a polarization conversion optical path shows it to drawing 12 . This illumination-light study system is an illumination-light study system for liquid crystal projectors for illuminating a liquid crystal panel (29). In order of an optical path, a lamp (20) UV(ultraviolet ray)-IR (infrared ray) cut-off filter (21), It has hologram (23) condenser lens (24) relay lens (25) 1/2 wavelength plate (26), trimming filter (27), and field lens (28) for an integrator rod (22); a polarization separation component (1 or 11), and color separation.

[0038] the light source (20a) to which a lamp (20) emits the illumination light, and the ellipse mirror (20b) which condenses the illumination light from the light source (20a) — since — it changes. The illumination light injected from the lamp (20) passes a UV-IR cut-off filter (21). Although what is necessary is just to prepare if needed, if a UV-IR cut-off filter (21) arranges a UV-IR cut-off filter (21) between the light source (20a) and a polarization separation component (1 or 11) and the ultraviolet radiation and infrared light other than the required light are intercepted, it can raise the lightfastness and the thermal resistance of a polarization separation component (1 or 11), and can raise the dependability of a polarization separation component (1 or 11).

[0039] Incidence of the illumination light which passed the UV-IR cut-off filter (21) is carried out to the integrator rod (22) of a kaleidoscope method. An integrator rod (22) is the vitreous humour of a multiple column configuration, or a hollow barrel which changes combining two or more mirrors; and equalizes the spatial energy distribution (namely, illumination distribution) of the illumination light by repeating incident light repeatedly and reflecting it on the side face. Since the injection end face of an integrator rod (22) has the screen of a liquid crystal panel (29), and a relation [ \*\*\*\* ], it can illuminate the screen of a liquid crystal panel (29) to homogeneity efficiently.

[0040] Incidence of the illumination light which injected the integrator rod (22) is carried out to a polarization separation component (1 or 11). A polarization separation component (1 or 11) divides the illumination light injected from the integrator rod (22) into P polarization and S polarization polarization and plane of polarization cross at right angles mutually. In this polarization separation, a polarization separation component (1 or 11) is



penetrated as it is, without P polarization diffracting in respect of a diffraction grating (2a or 7a), and S polarization deviates by the diffraction in a diffraction-grating side (2a or 7a). And according to this polarization separation, gap of an optical-axis perpendicular direction will arise in an image formation location (namely, light source image position) in P polarization and S polarization. P polarization and S polarization which injected the polarization separation component (1 or 11) are injected at an include angle which the color of is separated by the hologram for color separation (23), and is different for every color of RGB, and carry out incidence to the condenser lens for condensing (24). In addition, you may make it the configuration which separates the color instead of a hologram (23) by using the diffracted-light study components (surface relief mold etc.) of other classes, a color wheel, a dichroic mirror, etc.

[0041] Incidence of the illumination light which passed the condenser lens (24) is carried out to a relay lens (25). The relay lens (25) of two sheets relays the illumination light so that the injection end face of an integrator rod (22) and the screen of a liquid crystal panel (29) may become conjugate. Near the drawing location of a relay lens (25) (\*\*\*\*\* near the conjugation location of a diaphragm), 1/2 wavelength plate (26) is arranged as a plane-of-polarization rotation means so that only S polarization may carry out incidence. Since S polarization and P polarization carry out image formation near the drawing location of a relay lens (25) in the location which shifted mutually, it is possible to carry out incidence only of the S polarization to 1/2 wavelength plate (26). 1/2 wavelength plate (26) rotates the plane of polarization of S polarization 90 degrees of abbreviation so that the polarization condition of the injection light from a relay lens (25) may gather. S polarization is changed into P polarization by rotation of this plane of polarization, consequently all illumination light turns into P polarization. Thus, by using 1/2 wavelength plate (26) as a plane-of-polarization rotation means, plane of polarization can be rotated cheaply.

[0042] The illumination light arranged with P polarization illuminates the liquid crystal panel (29) which is a space light modulation element, after passing the trimming filter (27) for raising the color purity other than a condenser lens (24), and the field lens for condensing (28). Since the polarizer (un-illustrating) of a liquid crystal panel (29) is arranged at the sense which makes P polarization penetrate, there is almost no quantity of light loss by the polarizer, and achievement of the high lighting of efficiency for light utilization is attained to a liquid crystal panel (29). Moreover, incidence is carried out to a liquid crystal panel (29) at the include angle from which the illumination light of RGB differs mutually, and since the pixel corresponding to RGB is illuminated by the micro-lens array (un-illustrating) located in the illumination-light incidence side of a liquid crystal panel (29), a full color display with the veneer is attained. In addition, since a full color display will be attained if light carries out incidence at an include angle which is different for every color to the micro-lens array of a liquid crystal panel (29), the same lighting is possible even if it makes it the configuration which separates the color in respect of three die clo IKKU instead of separating the color by the hologram (23).

[0043] Since a polarization separation component (1 or 11) has the small incident angle dependency (refer to drawing 3), polarization separation can be performed at high effectiveness also to light with a big incident angle. Therefore, since efficiency for light utilization can be raised by polarization conversion of high effectiveness, a liquid crystal panel (29) can be illuminated brightly. Moreover, combination with 1/2 wavelength plate (26) can attain cheap polarization conversion. On the other hand, the large polarization separation means of an incident angle dependency does not have so good matching with the integrator rod (22) which injects the illumination light at a big include angle as PBS (polarizing beam splitter). Therefore, it is difficult to perform polarization separation at high effectiveness in the combination of PBS and an integrator rod (22). Since polarization conversion efficiency will also become low if polarization separation efficiency is low, the improvement in efficiency for light utilization is impossible.

[0044] In the display of a veneer method using the reflective mold liquid crystal panel in which a high-speed drive is possible, in order to secure brightness, especially polarization conversion is needed. Moreover, when adopting as a display a color sequential method (method which changes R, G, and B one by one using a color wheel etc.), the condensing section like the outlet of an integrator rod (22) is needed in order to arrange a color wheel. According to the combination of an integrator rod (22) and a polarization separation component (1 or 11) as shown in drawing 11 etc., though it is a compact configuration, brightness can be secured, and a color sequential method can be adopted. On the other hand, when the integrator of a lens array method is used, the configuration of the condensing section is difficult and also becomes causing enlargement of the whole illumination-light study system.

[0045] Drawing 12 shows the optical configuration of the illumination-light study system which performs different polarization conversion to drawing 13 in the cross section (condition seen from the side-face side) of a

polarization conversion optical path. the polarization part elongation according [ this illumination-light study system ] to a polarization separation component (1 or 11) — large — [— that is, if the point that 1/2 wavelength plate (26) is arranged is removed so that the angle of diffraction by the diffraction-grating side (2a or 7a) may correspond to] and it greatly, it is constituted like the illumination-light study system of drawing 12 . Therefore, the cross section (condition seen from the top-face side) of the color-separation optical path of this illumination-light study system is the same as drawing 11 . Since S polarization will deviate by big polarization part elongation as a whole when the angle of diffraction by the diffraction lattice plane (2a or 7a) is enlarged by making a diffraction-grating pitch small, the degree of freedom of each part arrangement of an illumination-light study system can be raised.

[0046]

[Effect of the Invention] since it has the composition that a transparence substrate is arranged proper to the diffracted-light study component which consists of a glass substrate and a resin layer according to this invention as explained above — manufacture — it is easy and a reliable polarization separation component can be realized.

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[Translation done.]

#### \* NOTICES \*

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- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.\*\*\*\* shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

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#### DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The sectional view showing the polarization separation component which has a sheet-like diffracted-light study component layer.

[Drawing 2] The graph which shows the wavelength dependency of the transparency effectiveness in the polarization separation component of drawing 1 , and diffraction efficiency.

[Drawing 3] The graph which shows the incident angle dependency of the transparency effectiveness in the polarization separation component of drawing 1 , and diffraction efficiency.

[Drawing 4] The sectional view showing the diffraction-grating side formation process of a compound die diffracted-light study component.

[Drawing 5] The sectional view showing the polarization separation component which consisted of diffracted-light study components of drawing 4 .

[Drawing 6] The enlarged drawing showing a part of polarization separation component (Z section) of drawing 5 .

[Drawing 7] The enlarged drawing showing the condition that the resin layer edge (part with weld flash) of the polarization separation component of drawing 5 was covered with the protective agent.

[Drawing 8] The enlarged drawing showing the condition that the resin layer edge (part without weld flash) of the polarization separation component of drawing 5 was covered with the protective agent.

[Drawing 9] The enlarged drawing showing the liquid crystal inlet part of the polarization separation component of drawing 5 .

[Drawing 10] The enlarged drawing showing the condition that the liquid crystal inlet part of the polarization separation component of drawing 5 was covered with encapsulant.

[Drawing 11] Drawing showing the optical configuration of the illumination-light study system equipped with the polarization separation component in the cross section of a color-separation optical path.

[Drawing 12] Drawing showing the optical configuration of the illumination-light study system equipped with the polarization separation component in the cross section of a polarization conversion optical path.

[Drawing 13] Drawing in which drawing 12 shows the optical configuration of the illumination-light study system which performs different polarization conversion in the cross section of a polarization conversion optical path.

[Description of Notations]

1 — Polarization Separation Component

- 2 — Diffracted-Light Study Component Layer
  - 2a — Diffraction-grating side
  - 3 — Liquid Crystal Layer (Optically Anisotropic Body Layer)
  - 4 — Opposite Plate (Transparence Substrate)
  - 4a — Orientation film
  - 6 — Glass Substrate
  - 7 — Resin Layer (Diffracted-Light Study Component Layer)
  - 7a — Diffraction-grating side
  - 10 — Diffracted-Light Study Component
  - 11 — Polarization Separation Component
  - 20 — Lamp
  - 20a — Light source
  - 21 — UV-IR Cut-off Filter
  - 22 — Integrator Rod
  - 25 — Relay Lens
  - 26 — 1/2 Wavelength Plate (Plane-of-Polarization Rotation Means)
  - 29 — Liquid Crystal Panel
  - B1 — Formation field of a resin layer
  - B-2 — Agenesis field of a resin layer
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[Translation done.]